PROJECTION OF THE NEGATIVE AFTER IMAGE IN THE FIELD OF THE CLOSED LIDS

By Frank Angell

In the preceding numbers of this Journal, the writer together with one of his students set forth the results of an investigation on the apparent distance of the negative after-image in the field of the closed eyes. Up to the time of printing, the writers had found no material bearing on the topic save casual references by Fechner and Hering. The fated article which, of course, had a Teutonic existence somewhere, has turned up in v. Graefe's *Archiv* for 1885 with Dr. G. Mayerhausen as sponsor and as title "Ueber die Grössenverhältnisse der Nachbilder bei geschlossenen Lidern" (*Abteilung* 2 S. 23-24). The results differ so widely from those published in the Journal as to call either for explanation or discussion or both.

Experimenting on himself, Mayerhausen finds that the negative after-image in the darkened field appears as large as the inducing object when the latter is set at a distance of two meters. In the case of the Stanford observers, three in number, unacquainted with each other's findings, the region of equality lay inside of eighteen centimeters from the cyclopean eye.

Mayerhausen's method was as follows: As inducing objects he used four white discs, 1, 2, 4, and 8 cm. in diameter respectively, and developed after-images from them at ten different distances from the eye, beginning with five meters and running down to 10 cm. When the after-image was at its maximum clearness, he opened his eyes and compared its diameter with the readings of a centimeter scale held in his hand. In this way, he made eighty readings, viz., two for each size after-image at each of the ten distances. The writer humbly submits that this is a less trustworthy procedure than that described in the Journal where the after-image with closed eyes was compared with the image projected on an adjustable screen until a region was found where the two images showed no appreciable difference. Within this region, after-images were induced and their size measured by projecting them on a ruled screen. The equating of the two forms of after-image was almost as accurate as if the images had been actual cardboard disks, successively compared. The estimation of the projected image was harder but nevertheless the size of the mean variation of the readings (from 4% to 10%) for the three observers showed that the judgments were based on actual if rough measurement.

Mayerhausen combines all his figures into a composite curve in which the abscissal distances are the distances of the inducing discs from the eye and the ordinates are the ratios of the diameters of the inducing discs to the estimated size of the corresponding after-images. The curve indicates a very rapid falling off in the size of the after-images from 10 to 50 cm., and a gradual decrease up to the farthest distance used, viz., five meters. At 30 cm. the image is more than twice as large as the disc itself; at 100 cm. it is 1.17

times as large and at 200 cm. as stated above, image and disc are equal.

Of course the obvious answer to the discrepancy of results is that the methods were different. Accordingly the next thing to be done was to try Mayerhausen's way of measuring after-images with a centimeter rule, though instead of the hand we ventured to use a tripod placed at a convenient distance. The results of these measurements are given below:

Observer *W. T. R.*, assistant in laboratory experiments in preceding investigation on after-images. May have looked for small images, but was simply given directions for repeating Mayerhausen's experiment. Each figure is the average of eight readings:

Distance of square from observer		1 m.	2 m.	3 m.	4 m.	5 m.
Estimated size (in mm.) of image of	8 cm. disc	12.6	9.8	6.7	4.8	2.8
	4 cm. disc	6.6	4.8	3.0	2.3	1.5
	2 cm. disc	3.0	2.2	1.7	1.1	1.1
	1 cm. disc	1.8	1.1	1.–	0.5	0.2

Observer *F. A.* Was observer in preceding investigation, anticipated relatively small size of images. Experimented only once with the 3 cm. and 4 cm. discs. Was usually unable to dectect the after-images from a one cm. disk placed at 3, 4 and 5 meters, and not alway when placed at 2 and 3 meters. When seen, the image was roughly estimated as somewhere near one millimeter.

Distance of 4 cm. disc from observer.	1 m.	2 m.	3 m.	4 m.	5 m.
Size of after-image in mm. (4 trials)	5.10	2.3	1.53	1.2	1 and less.

Observer *G. T.*, advanced student in Psychology, had not served in previous investigations and was unacquainted with its results. Experiments only with 1 cm. disc.

Distance of 1 cm. disc from observer.	1 m.	3 m.	5 m.
Size of after-image in mm. (5 trials)	2	1	0.5

These figures accord with the general experience of the laboratory. In the introductory laboratory course, the students are usually unable to find, at the outset, the after-image of the 1 cm. disc placed at a distance of 40 to 50 cms. as they usually look for an image which approximates the object in size instead of the minute figure of 2 or 3 mms. which they finally detect.

It is at this point that Mayerhausen's figures are wholly inexplicable to the writer. It is conceivable that with the larger discs one can imagine a greater or less distance of projection and so perhaps a greater or less size. But the images from a 1 cm. disc placed at 4 to 5 meters are simply minute gray points. If one uses a black disc on a white ground the after-image will be a point of faint light, not unlike a star of small magnitude. But Mayerhausen estimates the size of the after-image from the 1 cm. disc placed at a distance of 5 meters as from 4 to 6 mm. which is larger than our estimations for a 4 cm. disc acting from a distance of 2 meters. At the outset, however, Mayerhausen instances an experiment which he seems to consider eliminates the factor of distance in explaining the size of projected after-images. This crucial experiment he describes as follows: "If, in the after-image experiment, I fixate a distant wall, and while fixating, slowly push in a sheet of paper between my eyes and the wall (say at a distance of 30 cm.), the image now appearing

on the paper will retain exactly the same size which it formerly had on the wall." "Daraus geht zur Genüge hervor," he continues, "dass bei gleich bleibender Fixation es für die Grösse eines Nachbildes absolut gleichgültig ist, wo die Projectionsfläche liegt." This is surely a feeble lever for overturning so well-grounded a structure as the theory of the relation of size and distance of projection of after-images. For it is evident that what we have in this experiment is a blending of the wall and the paper to a common surface which is projected to the distance of either wall or paper. If the after-images of two discs say of 5 cm. diameter, placed 5 or 6 cms. apart, are projected on the wall and then the paper is pushed slowly in until its edge falls between the images of the disc, one may get two sizes of disc images, one corresponding to the distance of the wall, the other to the paper. In fact, Mayerhausen's 'blend' experiment is evidence against his argument, for the sizes of the after-images will correspond either to the supposed distance of the wall or of the paper, and to no other distance.

As distance of projection is not for Mayerhausen the main factor in determining size, convergence must play the chief rôle, and accordingly he concludes that equality of after-image and inducing object at the distance of two meters, is owing to the intersection of the optic axes at this distance. When the eyes are closed, he assumes that convergence at 2 meters forms, at first, a sort of state of provisional equilibrium, which passes over into parallelism of the axes in sleep (*op. cit.*, S. 25). He further assumes that when the object fixed is at a distance, say, of one meter, and the eyes are then closed to develop the after-image, the stronger convergence does not pass over into the state of equilibrium, but a lesser relaxation follows which in his case multiplies the size of the object by 1.17, though, of course, the retinal image is doubled in diameter.

It does not appear that Mayerhausen investigated the movements of the closed eyes when developing after-images. Assuming that the distance of projection depends on convergence, he concludes that the motions must have taken place to produce the results indicated by his figures.

But it certainly is a matter of no great difficulty to acquire the power of converging the eyes at will when closed or when in a dark room and when the trial is made it will not be found to have much influence on the size of the after-image. Hering says that he can alternately change parallelism of the optic axes for the greatest possible convergence without changing the apparent size of the after-image in the field of the closed eyes,[1] and the writer has not been able to note any regular change in the size of the after-image when repeating the experiment. It even makes no difference to the apparent size and position of the after-image if one eye is displaced by pressing on the bulb, a condition which, of course, with open eyes produces double-images.

It is unfortunate that, in this and other psychological investigations, observers obtaining such different results from the same problem can not come together and compare methods of work. The discrepancy is probably owing to some unnoted difference in the details of the operations which joint investigations could bring to light,—to the advancement of knowledge and the saving of printers' ink.

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[1] E. Hering, *Beiträge zur Physiologie,* I, 138.